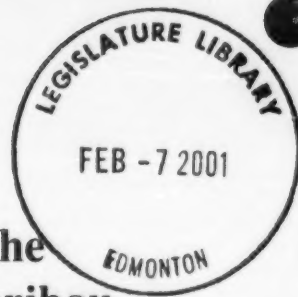


**Fisheries &
Wildlife
Management
Division**

**RESOURCE STATUS AND
ASSESSMENT BRANCH**



**Status of the
Woodland Caribou
(Rangifer tarandus
caribou)
in Alberta**

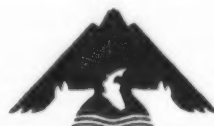
Elston Dzus



Alberta Wildlife Status Report No. 30



Alberta
ENVIRONMENT



**Alberta Conservation
Association**

**Status of the Woodland Caribou
(Rangifer tarandus caribou)
in Alberta**

Elston Dzus

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PREFACE

Every five years, the Fisheries and Wildlife Management Division of Alberta Natural Resources Service reviews the status of wildlife species in Alberta. These overviews, which have been conducted in 1991 and 1996, assign individual species to 'colour' lists that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A primary objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the 1996 *Status of Alberta Wildlife* review process, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are potentially at risk in the province (Red or Blue listed), that are of uncertain status (Status Undetermined), or which are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fisheries and Wildlife Management Division of Alberta Environment, and are intended to provide detailed and up-to-date information which will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information which will assist the Alberta Endangered Species Conservation Committee to identify species that may be formally designated as endangered or threatened under the Alberta Wildlife Act. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

Woodland Caribou (*Rangifer tarandus caribou*) are currently on the 'Blue List' of species that may be at risk in Alberta. Under the Alberta Wildlife Act, caribou are designated threatened because of reduced distribution, declines in regional populations and threats of further declines associated with human activities. This report summarizes available information on the Woodland Caribou as a step towards updating its status in the province.

The Woodland Caribou's primary winter food source is lichen and this is largely responsible for its preference for mature to old forests. This specialized food source, not normally used by other ungulates, allows the caribou to spatially separate themselves from other species and reduce the risk of predation. Predation by wolves is the primary cause of caribou death and the most significant limiting factor for this species. Other industry activities that may reduce caribou habitat suitability are resource extraction in the form of forestry, mining, petroleum and natural gas exploration and production, and agricultural expansion. Many of these activities create linear corridors that effect the movement and distribution of caribou and provide easier access for predators and humans.

Population and distribution of Woodland Caribou in Alberta have been reduced, but the number of caribou in the province remains largely unknown. There are extensive research and management programs ongoing in Alberta with the majority of research conducted in the last 10 years. Current land use guidelines for industry have proven to be ineffective in terms of providing for long term caribou conservation. Research and management undertaken by various regional standing committees have increased our knowledge of caribou ecology, but advancing this knowledge to better understand the effects of human activities on caribou is critical.

ACKNOWLEDGEMENTS

Information for this report was gathered from a number of sources, and I would like to acknowledge those individuals and agencies who contributed information, both directly or indirectly. Contributors denoted with an asterisk (*) provided information used for determining the current range or jurisdictional status. The following individuals are listed alphabetically but deserve equal consideration: Ted Armstrong* (Ontario Ministry of Natural Resources); Rhys Beaulieu (Saskatchewan Environment and Resource Management); Kent Brown (Terrestrial & Aquatic Environmental Managers Ltd.); Stan Boutin (University of Alberta); Gordon Court (Alberta Natural Resources Service); Rehaume Courtois (Quebec); Doug Culbert (Alberta Natural Resources Service); Christine Doucett* (Newfoundland); Rick Farnell* (Yukon Territorial Government); Christine Found* (Alberta Natural Resources Service, formerly with Government of Newfoundland & Labrador, Wildlife Branch); Mike Flannigan; Anne Gunn (Northwest Territories); Mark Heckbert (Alberta Natural Resources Service); Doug Heard (B.C. Environment, Wildlife Branch); Gerry Kuzyk (University of Alberta); Dave Laing (Alberta Lands and Forest Service); Ron Larche* (Manitoba Natural Resources); Ken Lowe (Alberta Lands and Forest Service); Gerry Lynch (independent ecologist); Mike Norton (formerly Alberta Conservation Association); Emma Pharo (formerly University of Alberta); Ken Rebizant (Manitoba Natural Resources); Christoph Rohner (University of Alberta); Gerry Samide (Samide Engineering Ltd.); Ian Thompson; Tim Trotter (Saskatchewan Environment and Resource Management); Dale Vitt (University of Alberta); and Ralph Woods (Alberta Lands and Forest Service). I am especially indebted to the dialogue and support provided by the multitude of researchers and supporting agencies associated with the Boreal Caribou Committee.

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Isabelle Michaud (Alberta Conservation Association) and Sherry Feser (Alberta Conservation Association) provided editorial guidance, Jane Horb prepared the figures and Brian Huffman created the cover artwork. Preparation and production of this report were funded by the Wildlife Management Enhancement Fund of Alberta Natural Resources Service and the Alberta Conservation Association.

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INTRODUCTION

Caribou (Rangifer tarandus) are currently found in all Canadian provinces and territories except Prince Edward Island, Nova Scotia and New Brunswick. Caribou vary in abundance across their North American range, with the world's largest herd residing in Quebec and Labrador (Couturier et al. 1996). The woodland subspecies (R. t. caribou) is distributed across the forested and mountainous regions of Canada, including northern and west-central Alberta. The boreal and southern mountain populations of Woodland Caribou are considered 'threatened' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2000). The Atlantic (formerly Gaspé) population in Quebec is considered 'endangered' (COSEWIC 2000). Woodland Caribou are on Alberta's 'Blue List' of species that may be at risk of declining to non-viable population levels in the province (Alberta Wildlife Management Division 1996) and are designated 'threatened' under the provincial Wildlife Act. Considerable research has been done on caribou ecology in Alberta over the past 20 years. This report summarizes past and ongoing research on Woodland Caribou ecology in Alberta as a step in updating the species' current status designation in the province.

Ecotypes (a form of a given species with characteristic adaptations) are frequently used in the description of caribou (Edmonds 1991, Thomas 1995) because of the tremendous variation in behavior, habitat use patterns, or morphology of caribou from different regions. In this document, Woodland Caribou that live year round in forested habitat will be referred to as 'boreal' ecotype, while caribou that winter in forested foothills and migrate to alpine mountain habitat during summer will be

referred to as 'mountain' ecotype (see Edmonds 1991).

HABITAT

Woodland Caribou typically rely on large tracts of mature to old forests that contain the caribou's primary winter food - lichens. Habitat use by the two Woodland Caribou ecotypes in Alberta contrasts most during spring, summer and fall (Edmonds and Bloomfield 1984). The migratory nature of most mountain caribou inhabiting Alberta's eastern slopes takes them from high elevation alpine habitats in spring, summer and fall to foothills forests in the winter. Boreal ecotype caribou inhabiting forests of northern Alberta make extensive movements throughout the year (Hornbeck and Moyles 1995, Stuart-Smith et al. 1997) but most do not make predictable migrations and therefore habitat use does not differ on a seasonal basis.

Lichens are an important food source for caribou and thus influence habitat use and distribution. Due to their extremely slow growth and limited dispersal mechanisms, lichens are found primarily in old forests. This fact contributes to the affinity of Woodland Caribou to relatively old forests (Bjorge 1984, Stepaniuk 1997). Alberta's boreal ecotype caribou are typically found in peatland (muskeg) complexes dominated by black spruce (Picea mariana) and larch (tamarack, Larix laricina; Fuller and Keith 1981, Edmonds and Bloomfield 1984, Bradshaw et al. 1995, Hornbeck and Moyles 1995, Anderson 1999). Caribou movements in northeastern Alberta were shown to be constrained (98.6% of locations) by the boundaries of peatland complexes (Stuart-Smith et al. 1997). This pattern of lowland habitat use, in combination with varying use of lichen-rich stands of jack pine (Pinus banksiana) or lodgepole pine (P. contorta) are common to caribou in non-

* See Appendix 1 for definitions of selected status designations.

mountainous areas (Darby and Pruitt Jr. 1984, Schaefer and Pruitt Jr. 1991, Rettie and Messier 2000, Schneider et al., 2000). Recent work in north-central Alberta has shown that even in areas where small peatlands are interspersed in an upland matrix, caribou select treed bogs and fens (Morton and Wynes 1997, Boreal Caribou Research Program 1998, Anderson 1999, Boreal Caribou Research Program 1999a). Upland stands of trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), paper birch (*Betula papyrifera*) and balsam fir (*Abies balsamea*) are seldom used or are avoided (Fuller and Keith 1981, Bradshaw et al. 1995).

Habitat selection by migratory mountain caribou changes seasonally. The breeding season, or rut, typically takes place in alpine or subalpine meadows (Edmonds and Smith 1991). In winter, mature and old lodgepole pine or mixed pine/spruce/fir forests are most commonly used (Edmonds and Bloomfield 1984). Mountain caribou in some ranges (e.g., South Jasper/Whitegoat; see Figure 1 for caribou range names) now reside in the mountains year round, but move from low elevation winter ranges to upper subalpine and alpine habitats in the summer (Brown and Hobson 1998). The migratory A La Peche herd has not left the mountains since 1997 (Alberta Environment, unpubl. data) and the reasons for the recent abandonment of their foothills winter range are unknown. A small population (minimum estimate of 60 animals) of caribou residing in the Little Smoky range are non-migratory, and are the only caribou remaining in west-central Alberta that inhabit forested lowlands year round; they are considered to be boreal ecotype animals (Brown and Hobson 1998).

Relative safety from predation is a key feature of habitat used by Woodland Caribou. The susceptibility of caribou to wolf predation has

led to patterns of habitat use that separate them from other ungulates that cohabit the same geographic areas (Bergerud and Page 1987, Seip 1992). For mountain caribou, this 'spatial separation' occurs when they occupy different winter habitat than other ungulates and/or when mountain caribou make migrations to calve at higher elevations than moose, deer or elk (Edmonds and Smith 1991, Seip 1992). Boreal caribou in Alberta do not migrate (Stuart-Smith et al. 1997), however this ecotype separates itself from other ungulates by occupying habitat that has a lower density of other ungulate species year-round (Boreal Caribou Research Program 1998, Boreal Caribou Research Program 1999b, James 1999). The risk of predation is further reduced in Woodland Caribou residing in the mid-continent by existing at very low population densities of approximately 0.03 to 0.12 caribou per square kilometer (Seip 1991, Bergerud 1992, Stuart-Smith et al. 1997). The availability of extensive range 'space' is thought to be an important habitat characteristic that allows caribou to avoid predation (Bergerud 1980, Bergerud et al. 1984).

Unlike Barren-ground Caribou (*R. t. groenlandicus*; Adams and Dale 1998a), calving sites in Alberta are not associated with easily identifiable 'calving grounds'. Pregnant female caribou of the boreal and mountain ecotype disperse on the landscape for calving, though individual females often show fidelity to previous calving locales (Edmonds and Smith 1991, Hornbeck and Moyles 1995, Morton and Wynes 1997). Calving site habitats in west-central Alberta are quite variable (e.g., alpine, subalpine forest, treed and open muskeg; Edmonds and Smith 1991). Boreal caribou calve in lowland habitats (muskeg bogs and fens; Morton and Wynes 1997, Boreal Caribou Research Program, unpubl. data), but characteristics of specific microsites are not known.

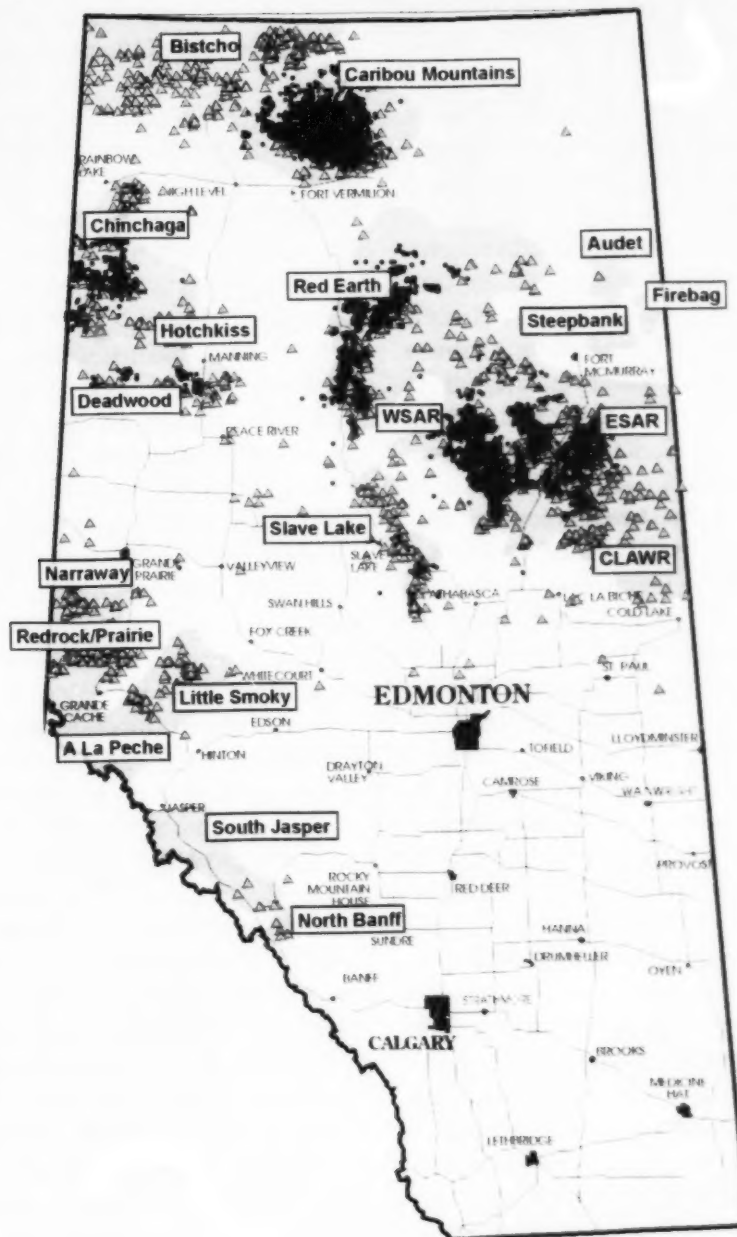


Figure 1. Caribou range names in Alberta (adapted from Alberta Fish and Wildlife 1993). WSAR West side of Athabasca River; ESAR = East side of Athabasca River; CLAWR = ColdLake Air Weapons Range.

CONSERVATION BIOLOGY

Caribou are medium-sized members of the deer family. They are recognized by their brown pelage, cream-coloured neck and mane, and large, intricate, forward-curving antlers. Males and most females have antlers, although the females' are smaller. Caribou are well adapted to harsh winter conditions (White et al. 1981, Telfer and Kelsall 1984). Their large, crescent-shaped hooves and relatively long legs are useful for digging through snow to reach their winter food (e.g., lichens), and provide effective weight distribution for locomotion over snow or muskeg (Fancy and White 1985, Klein and Fancy 1987, Klein 1992). Other adaptations to winter conditions include short extremities (ears and tail), and hollow hair that provides excellent insulation and covers the entire body including the muzzle. To further reduce heat loss, caribou have a slower metabolism and a reduced rate of movement in most late winters when deep, crusted snow makes travel energetically expensive (Banfield 1977, Klein 1992, Schneider et al. 1999). Despite these adaptations, fat reserves accumulated in summer are depleted during winter (Dauphine Jr. 1976, Adamczewski et al. 1987, Gerhart et al. 1996a). Pregnant females divert nutrients to their growing fetuses throughout the winter with costs to the mother increasing exponentially during gestation (Robbins 1983). Long, harsh winters with deep, crusted snow can thus compromise body condition and survival of adults, juveniles, and unborn fetuses (Adams et al. 1995).

Mountain and boreal ecotype Woodland Caribou differ in their seasonal movement patterns. Most mountain caribou in Alberta are migratory and make seasonal migrations between alpine or sub-alpine summer range (in both Alberta and adjacent British Columbia) and forested foothills winter range (Edmonds and Bloomfield 1984, Brown and Hobson

1998). Boreal ecotype animals wander extensively throughout the year but typically show considerable overlap between winter and summer ranges (Stuart-Smith et al. 1997).

The breeding season, or rut, occurs in early- to mid-October (Edmonds and Bloomfield 1984). Bulls tend to be polygamous, collecting and defending harems of twelve to fifteen cows (Banfield 1977). Males eat little during the rut (Banfield 1977) and may lose up to 25% of their body weight (Bergerud 1983). By November, mountain ecotype animals begin to move to their wintering range, while boreal ecotype caribou disperse into smaller groups throughout their annual home range.

Caribou have a gestation period of approximately 7.5 to 8 months (Banfield 1977). In northern Alberta most calves are born in the first two weeks of May (Morton and Wynes 1997). This is earlier than in west-central Alberta where most calves are born in the first week of June (Edmonds and Bloomfield 1984, Edmonds 1988, Edmonds and Smith 1991), and is also earlier than several other areas of North America (Hatler 1986, Brown and Theberge 1990).

Caribou exhibit low reproductive potential. Adult cows typically begin producing young when they are three years of age and only produce a single calf annually (Adams and Dale 1998b). Females that are 1.5 years old may breed and produce young as two-year-olds depending on nutrition (Dauphine Jr. 1976, Adams and Dale 1998b, Rettie and Messier 1998). Recent work in Alberta has shown pregnancy rates to be very high in females over 2.5 years of age (Edmonds and Smith 1991, Stuart-Smith et al. 1997, Boreal Caribou Research Program 1998). Similarly, visual observations of radio-collared females with newborn calves revealed calf production to be high (>80% of all females; Morton and Wynes

1997). These high and relatively invariant rates of pregnancy and calf production are comparable to Barren-ground and Woodland Caribou herds elsewhere in Canada (Bergerud 1980, Bergerud 1983).

Juvenile survival (i.e., in the first year of life) for caribou is highly variable both within and between years. A common temporal pattern shown in the first year is for caribou calf mortality to be highest in the first 30 days after birth (Mahoney et al. 1990, Stuart-Smith et al. 1997). Survival rates approach adult levels after the first year of life (Davis et al. 1988, Whitten et al. 1992). In northern Alberta, estimates of calf survival to ten months of age, expressed as number of calves relative to the number of adult females, has varied between 7.4 and 46 calves per 100 cows¹ (Table 1, Boreal Caribou Research Program, unpubl. data). In west central Alberta, estimated calf survival to five months of age (the end of summer), based on a sample of radio-collared females, has varied between 0 and 60 calves per 100 cows (Alberta Environment, unpubl. data). The Little Smoky herd has shown the lowest estimates of recruitment over the last three years with calves comprising only 4%, 5%, and 5% of the late summer population in 1998, 1999, and 2000 respectively. This herd had calves comprising just 1.2% of the winter population in 2000 (Alberta Environment, unpubl. data). Bergerud (1974) suggested caribou populations with less than 10% calves in late winter are likely declining. Variability in juvenile survival plays a critical role in determining population dynamics of ungulates such as Woodland Caribou (Gaillard et al. 1998).

Survival of adult caribou is typically much

¹ Note: actual calf survival rates to ten months of age will be slightly higher than values in Table 1 because only about 90% of adult female caribou produce a calf.

higher than juveniles, and shows less year to year variation. Edmonds (1988) reported an annual survival rate of 78% for adult mountain and boreal ecotype caribou in west-central Alberta during the early 1980s. A more recent examination in this study area reported a higher annual survival rate for both mountain and boreal ecotype animals of 93% and 85%, respectively (K. Smith, pers. comm.). Annual survival of adult Woodland Caribou in the Birch Mountain area of northeastern Alberta has been reported at 85% (Fuller and Keith 1981) and 88% for a study area south of Fort McMurray (Stuart-Smith et al. 1997). More recent work in five northern Alberta study areas shows annual adult survival varied from 74% to 100% (Table 1; Boreal Caribou Research Program, unpubl. data; calculated according to Pollock et al. 1989). Survival rates of adult female Woodland Caribou in Alberta are comparable to those found in other areas of Canada (Bergerud 1980, Hearn et al. 1990, Seip 1992, Rettie and Messier 1998).

Predation, primarily by wolves, is recognized by most authorities as the most important natural cause of death in caribou populations (Bergerud 1988, Edmonds 1988, Seip 1992, Boertje et al. 1996, Stuart-Smith et al. 1997, Boertje and Gardner 1998). Ongoing research of the Boreal Caribou Research Program supports the contention that predation is the primary cause of death for adult caribou (Figure 2). In addition, others indicate that bears (*Ursus* spp.), Coyote (*Canis latrans*), Wolverine (*Gulo gulo*) and Canada Lynx (*Lynx canadensis*) may also be predators on caribou in forested habitats (Mahoney et al. 1990, Stephenson et al. 1991, Ballard 1994). In addition to predation, mortality factors for calves also include starvation, inclement weather, and reduced size at birth after hard winters (Bergerud 1983).

In Alberta, terrestrial lichens constitute the bulk of the Woodland Caribou's winter diet

Table 1. Adult female survival and calves per 100 adult females for caribou populations in northern Alberta, May 1993 - April 2000.

	1993/94			1994/95			1995/96			1996/97			1997/98			1998/99			1999/2000			Average ⁱⁱ
	n ⁱⁱⁱ	S ^{iv} (s.e)	c ^v	n	S (s.e)	c	n	S (s.e)	c	n	S (s.e)	c	n	S (s.e)	c	n	S (s.e)	c	n	S (s.e)	c	Adult Survival
West Side Athabasca River	18	94 (6)	28	25	89 (6)	22	42	83 (6)	20	37	88 (5)	29	30	93 (5)	36	32	89 (6)	26	44	83 (5)	18	88.5
East Side Athabasca River	31	89 (6)	10	33	89 (5)	22	44	85 (5)	20	36	94 (4)	15	31	83 (7)	vi	25	88 (6)	37	23	91 (6)	28	88.5
Red Earth					vii	9	22	82 (8)	25	19	74 (10)	18	14	100 (7)	46	14	79 (11)	15	27	100	12	86.1
Caribou Mtns.					viii	11	16	100	16	16	100	24	29	81 (7)	10	25	96 (4)	12	23	77 (9)	7	90.3
CLAWR ^{ix} Alberta																22	95 (5)	19	21	95 (5)	14	95.2
CLAWR Saskatchewan																23	90 (6)	32	21	81 (9)	19	85.1

ⁱ Saskatchewan side of the Cold Lake Air Weapons Range included for comparison as it is one of the study areas of the Boreal Caribou Research Program.

ⁱⁱ Average annual adult female survival rate calculated as a geometric mean over entire period of sampling (Steel & Torrie 1980); calculation done as sample size in some years was low (<20) and as such losses or survival of a few animals can cause large variation in annual survival rate. Not calculated for calves as the ratio was always based on an adequate sample of adult females (n > 50, typically n > 100).

ⁱⁱⁱ n refers to the maximum number of adult female caribou monitored during the year. Note: total number of females is less than the sum across years as many females survived from one year to the next.

^{iv} S refers to adult female survival as a percent. Calculated as the Kaplan-Meier estimator of survival rate (Pollock et al. 1989), using a computer program designed by C. Krebs (University of British Columbia).

^v Proportion of adult females (cows) seen with calves in late February/early March of year following birth (i.e., calves per 100 cows at 10 months of age); this value is used as an estimate of recruitment.

^{vi} Spring calf survey not done on east side of Athabasca river due to budgetary constraints.

^{vii} Adult survival not calculated for the year as collared only occurred in January; calf surveys were flown in March.

^{viii} Adult survival not calculated for the year as collared only occurred in January; calf surveys were flown in March.

^{ix} CLAWR = Cold Lake Air Weapons Range

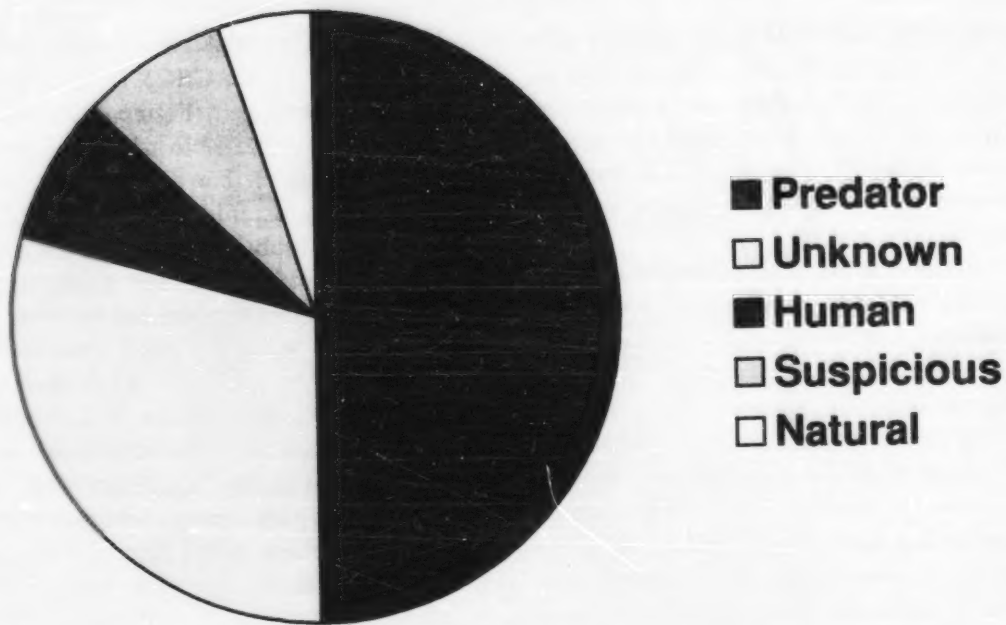


Figure 2. Causes of mortality for radio-collared adult female caribou (n=102) in northern Alberta, 1992 to June 2000 (Boreal Caribou Research Program, unpublished data). 'Suspicious' means humans were suspected in causing the death of the caribou; criteria included sudden loss of signal with no indication of transmitter malfunction and battery was still within the expected life span charge.

(Thomas et al. 1996, Morton and Wynes 1997). By exploiting a food source not normally sought by other ungulates, Woodland Caribou can spatially separate themselves from other species to reduce predation risk. Arboreal lichens (those growing on trees) are important food items in the diet of some caribou populations, especially those inhabiting mountainous areas with deep snow (Simpson et al. 1985). Caribou in Alberta and Saskatchewan occasionally feed on arboreal lichens, and this food source may be most important when deep or crusted snow makes accessing terrestrial lichens difficult (Thomas and Armbruster 1996, Thomas et al. 1996). The summer diet of caribou is much more varied, including terrestrial lichens, shrubs, grasses, sedges, horsetails, and forbs (Boertje 1984, Thomas and Armbruster 1996, M. Heckbert, pers. comm., D. Thomas, pers. comm.).

DISTRIBUTION

1. Alberta. - The distribution of Woodland Caribou in Alberta has experienced a reduction in extent relative to its historic range. While a detailed description of historic caribou distribution in northern Alberta has not been compiled, Soper (1964) described the former range of Woodland Caribou in the northern part of the province as the "whole of northern Alberta south to the lower limits of mixedwood forest (approximately Cold Lake; Lac la Biche; Barrhead) and south in comparable, western environment to about the latitude of Sundre; now absent in the major part of that region." Edmonds and Bloomfield (1984) reviewed historic records of caribou distribution in west central Alberta and documented that caribou have disappeared or remain as fragmented populations in many parts of the Alberta Rocky Mountains (see also Soper 1970). Several

recently occupied caribou ranges have also been observed to contract or disappear (e.g., Deadwood, Slave Lake, northern/western portions of Little Smoky, northern part of Calahoo Lake, Pinto/Nose Creek area; D. Hervieux, D. Moyles, K. Smith, pers. comm.).

By combining information on habitat use, radio telemetry studies, incidental sightings and local knowledge, a comprehensive picture of the current distribution of Woodland Caribou in Alberta emerges (Figure 3). Despite documented range recession, it is unlikely that Woodland Caribou distributions were as uniformly distributed as early reports indicated. Current knowledge of habitat use and ecological factors such as spatial separation almost certainly dictated low-density populations that likely occurred as a discontinuous distribution. It is for these reasons, combined with the difficulties of surveying low-density populations of cryptic Woodland Caribou, that defining habitat is probably the best approach to build base maps showing the potential distribution of caribou in northern Alberta (Bradshaw et al. 1995).

In Alberta's regional caribou land-use guidelines (Northeast Regional Standing Committee on Woodland Caribou (NERSC) 1997, Northwest Regional Standing Committee on Woodland Caribou (NWRSCC)

1997, West Central Alberta Caribou Standing Committee (WCACSC) 1996), 'caribou management zones'² (Figure 4) are based on identification of suitable habitat and available information on caribou distribution. Resource extraction companies (e.g., petroleum and natural gas, timber, peat mines) are asked to follow specific land-use guidelines for operations within caribou management zones. It should be noted that some areas known to be occupied by caribou were excluded from caribou management zones for administrative and other reasons³. Also some areas recently abandoned by caribou (e.g., Pinto/Nose Creeks, D. Hervieux, pers. comm.) were excluded from the management zones even though habitat potential for caribou remains. Maps of caribou management zones are periodically reviewed as new information on caribou habitat and distribution is acquired. The caribou management zones in the Northeast Boreal Region were established based on locations of radio-collared caribou relative to habitat associations (Bradshaw et al. 1995, G. Hamilton, pers. comm.). In the Northwest Boreal Region, caribou management zones were based on a combination of radio telemetry studies, surveys, local knowledge, analysis of land-sat imagery, and habitat associations (D. Moyles, pers. comm.). In west central Alberta, the boundaries of caribou management zones were developed using local knowledge,

² The caribou management zones referred to in this document are labelled as 'caribou management zones' in the Northwest Boreal Region, 'caribou restriction zones' in the Northeast Boreal Region, and 'caribou planning areas' in west central Alberta. For simplicity all caribou-related management and restriction zones in the province are called caribou management zones in this document.

³ Examples of caribou range areas not placed in caribou management zones include: Jasper/Banff/Wood Buffalo National Parks and the Cold Lake Air Weapons Range where provincial regulators do not have jurisdiction, the areas south/southeast of Christina Lake (T 76 R 7 W4M), and east of Lesser Slave Lake (T 73, 74 R5 W5M), and the heavy oil development area east of Wabasca (T 79-83, R 22-23 W5M) where regulators deemed industrial operations were already too intense to effectively implement new land use guidelines for caribou conservation, as well as the Calahoo Lake area (T68 R12,13,14 W6M) where the demand for new timber harvesting was high. Also some caribou ranges were excluded due to the presence of only small and isolated caribou herds.

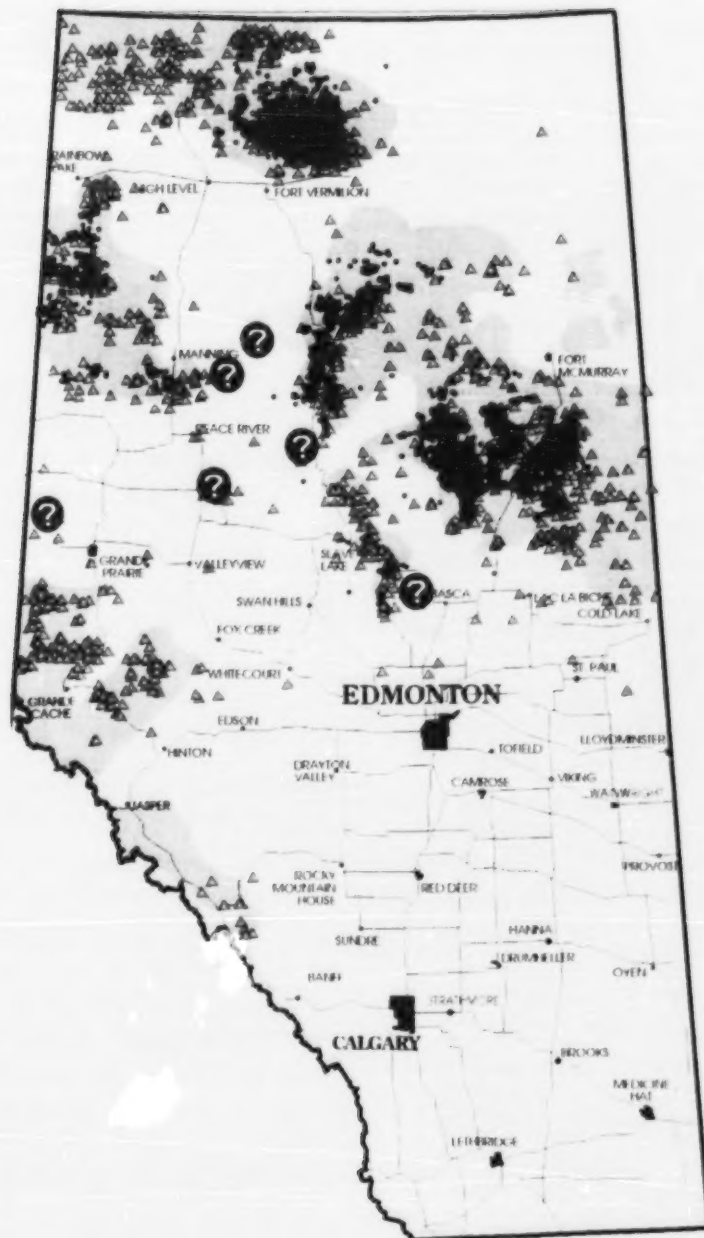


Figure 3. Distribution of Woodland Caribou in Alberta. The triangles are observations of caribou from several sources (see 'Distribution' section above), the dots are telemetry points, and the question marks are areas with several sightings or potentially suitable habitat. These observation and telemetry points were recorded from 1967-2000.



Figure 4. Woodland Caribou management zones (shaded areas) based on the identification of suitable habitat and/or current caribou distribution in Alberta.

radiotelemetry data, and aerial and ground-based survey data collected between 1979 and 1996 (K. Smith, pers. comm.).

Other information sources have been compiled to clarify the current distribution of Woodland Caribou in Alberta. To augment knowledge of caribou distribution, some wildlife managers have instituted a system of sighting cards whereby details of caribou sightings are gathered from the public. These sightings are entered in a provincial Biodiversity Species Observation Database maintained by Alberta Environment and Alberta Conservation Association. Many resource extraction companies have involved their employees in this sighting card program. Additional information on the distribution of caribou in Alberta has come from caribou sightings recorded during surveys flown for other big game species.

2. Other Areas. - The distribution of Woodland Caribou in North America has receded northward since the turn of the century (Figure 5; Soper 1964, Bergerud 1974, Cumming and Beange 1993). The southern limit of Woodland Caribou distribution east of the Rocky Mountains historically followed the boreal forest, south into the northeastern United States (Maine, Minnesota, Michigan, New Hampshire, Vermont, Wisconsin; U. S. Fish and Wildlife Service 1998) and the Canadian Maritimes. Woodland Caribou currently occur across Canada, extending north into the Northwest Territories, Yukon and Alaska, and south into Washington and Idaho. The northward contraction of the caribou's range has been most extensive in eastern Canada (Bergerud 1974, Cumming and Beange 1993, Crête et al. 1994). Caribou likely prefer certain habitats which may not be found throughout the range indicated in figure 5. For simplicity, the distribution of caribou outside of Alberta is shown as continuous.

Descriptions of current caribou distribution vary greatly in detail. Yukon and British Columbia depict herd boundaries, interspersed with low density areas (Farnell et al. 1998, Heard and Vagt 1998). Woodland Caribou in the Northwest Territories range from the Alberta border north to the tundra, west of Great Bear and Great Slave Lakes (Edmonds 1991). Relatively little is known about the status of these forest-dwelling caribou in the Northwest Territories. The former west coast population on the Queen Charlotte Islands went extinct by the 1920s (COSEWIC 2000). In Saskatchewan, Woodland Caribou distribution is vaguely presented as an area of the central and northern parts of the province between 54° N and 58° N; pockets of known populations have been highlighted by recent research (Rettie et al. 1998). Because of similarities in habitat types in northern Alberta and areas south of the Precambrian Shield in Saskatchewan, habitat associations established by Rettie and Messier (2000), Bradshaw et al. (1995), Anderson (1999) and ongoing studies of the Boreal Caribou Research Program should provide sufficient information to significantly refine the probable distribution of caribou in Saskatchewan. The distribution of Woodland Caribou in Manitoba is presented as discrete ranges; recent telemetry projects in Manitoba have shown that some former 'herds' likely form a larger metapopulation (R. Larche, pers. comm.). Cumming and Beange (1993) depict the southern boundary of contiguous Woodland Caribou distribution in Ontario (1990) as a line extending as far south as about 50° N latitude. Woodland Caribou in Ontario historically ranged as far south as 46° N, and six remnant herds still persist south of the line of current continuous distribution (populations are named according to their locations: Slate Islands, Pic Island, Pukaskwa National Park, Caramat, Flanders Township, and Hagarty Road; Euler et al. 1976, Darby et al. 1989, Cumming and Beange 1993). In Quebec, there



Figure 5. Distribution of Woodland Caribou in North America (adapted from Gray 1999). The distribution of caribou outside of Alberta is shown as continuous but may not be.

are numerous small herds inhabiting the boreal forest between 49° N and 55° N. In the boreal forest between 48° N and 49° N there are three small, sedentary caribou populations (the Val D'Or herd, the Grands Jardins herd and the Gaspésie herd in Gaspésie Conservation Park; Crête et al. 1994, Couturier et al. 1996). The large migratory Leaf River and George River herds in northern Quebec and Labrador are now considered by many to be Barren-ground Caribou (Couturier et al. 1990, Gray 1999). Newfoundland has scattered herds that occupy most of their historic range (Mahoney et al. 1998, C. Doucet, pers. comm.). Woodland Caribou were extirpated from Prince Edward Island before 1873 and from New Brunswick and Nova Scotia by the 1920s (Miller 1993).

POPULATION SIZE AND TREND

1. Alberta. - Development of a census technique for Woodland Caribou in Alberta is impeded by factors such as the low density and clumped distribution of caribou, their cryptic coloration, and their habit of remaining in coniferous forests during the winter. Significant efforts to develop population census techniques have been unsuccessful to date, but research is ongoing to develop suitable sampling protocols. Indices of caribou population dynamics are now used throughout the province to monitor population trends. Therefore, there are no accurate estimates of caribou population size in Alberta.

Despite the absence of reliable censusing techniques, there have been several attempts in recent years to estimate the size of Alberta's Woodland Caribou population. These estimates are typically presented as ranges of values and are largely based on professional judgement only. Edmonds (1986) estimated 1324 to 1868 Woodland Caribou in Alberta and later revised this estimate to 3300 (Edmonds 1991); (Ferguson and Gauthier

1992) reported 3000 to 3500; and the most recent estimate is 3600 to 6700 (with 600 – 750 of these being mountain ecotype caribou; Alberta Woodland Caribou Conservation Strategy Development Committee 1996). Contrary to apparent increases in population estimates from 1986 to 1996, most authorities contend that there has been a decline in Alberta's caribou population size and amount of occupied range since 1900 (Edmonds and Bloomfield 1984, Brown and Hobson 1998). The increase in caribou population estimates in the past decade is likely the result of increases in survey efforts and improvements in our understanding of caribou distribution in Alberta. Bradshaw and Hebert (1996) reviewed purported long-term declines in Woodland Caribou numbers in Alberta, and found no reliable data to support or refute the general perception of population declines. On the whole, there have been reductions in some populations and the distribution of caribou in Alberta has contracted, but the number of Woodland Caribou currently in Alberta remains largely unknown.

Current caribou population estimates are consistently much less than 1000 caribou for all identified individual caribou ranges in Alberta (Alberta Fish and Wildlife 1993, M. Heckbert, D. Hervieux, K. Morton, D. Moyles, K. Smith, and B. Wynes, pers. comm.). Between 1995 and 2000, the highest total count surveys on individual boreal caribou ranges have produced minimum counts ranging from 62 individuals in the Little Smoky (West-Central Alberta Caribou Standing Committee unpub. data) to 263 individuals in the Caribou Mountains (Boreal Caribou Research Program unpub. data). For individual mountain caribou ranges, surveyed between 1993 and 2000, these numbers were between 42 individuals in the Narraway and 187 individuals in the Redrock/Prairie Creek Range (West-Central Alberta Caribou Standing Committee unpub. data).

Caribou ranges and populations in Alberta (Figure 1) are largely distinct, with little movement by individual radio-collared caribou observed between ranges (Appendix 2). However, since most radio collars are put on female caribou, information about the movements of male caribou is limited. Therefore, inter-range movements may be somewhat under estimated.

Work initiated in west-central Alberta in 1980, and in northern Alberta in 1989, is focused on the assessment of adult and juvenile survival to estimate population trends based on mathematical relationships between estimates of adult survival, reproduction (pregnancy rates and production of young), and survival of juveniles to recruitment (e.g., Hatter and Bergerud 1991). An extensive monitoring program of radio-collared caribou allows researchers to determine annual survival rates for adult caribou, but logistical complications prevent large-scale calf-collaring projects in Alberta. Instead, information on calf survival comes from herd composition surveys.

Stuart-Smith et al. (1997) used a life table approach to compare adult and juvenile survival. They reported that Woodland Caribou in a 20,000 km² area of boreal forest south of Fort McMurray had a population rate of increase of $r = -0.08$ indicating the population was declining. However, there was insufficient data to determine if the rate of increase was significantly different from zero. Appendix 3 shows the relationship between the exponential rate of increase (r) and the percent change in population size that would be observed assuming no change in ' r ' over ten years. The value depicted by Stuart-Smith et al. (1997) would have lead to a 55% reduction in one decade if indeed $r = -0.08$ was accurate and did not vary.

Population change can be related to a variety of factors including changes in production of young, survival to breeding age, or adult survival. Production of young is relatively constant for Woodland Caribou, whereas there is some variability in adult, and to a much greater extent, juvenile survival (see 'Conservation Biology' section, above). Figure 6 demonstrates the relationship between adult survival, juvenile survival and the exponential rate of increase (r). For the variability found in juvenile survival (10% to 40%) seen in northern Alberta in the 1990s, adult survival must be greater than 85% to show a positive population growth rate. Figure 7 depicts data for adult and juvenile survival from six study areas in northern Alberta relative to isopleths that depict stable populations, 20% and 50% declines in 10 years (Boreal Caribou Research Program, unpubl. Data). Figures 8 and 9 present the cumulative percent change in these boreal caribou populations over the study period (Analysis prepared by T. Szkorupa (Alberta Natural Resources Service) using data from Table 1). These analyses for six study areas in northern Alberta suggest that caribou populations in most boreal ranges are declining. Caribou in the Red Earth area and Caribou Mountains have shown the most dramatic declining trends. Further analyses are underway to understand factors that are influencing these trends and to model the effects of annual variability in adult and juvenile survival on population trends.

Estimated cumulative percent change for three west-central Alberta caribou populations are shown on Figure 10 (analysis provided by C. Rohner (University of Alberta) using West-Central Alberta Caribou Standing Committee unpubl. Data). This analysis indicates high levels of population decline for the A La Peche and in particular for the Little Smoky caribou herds.

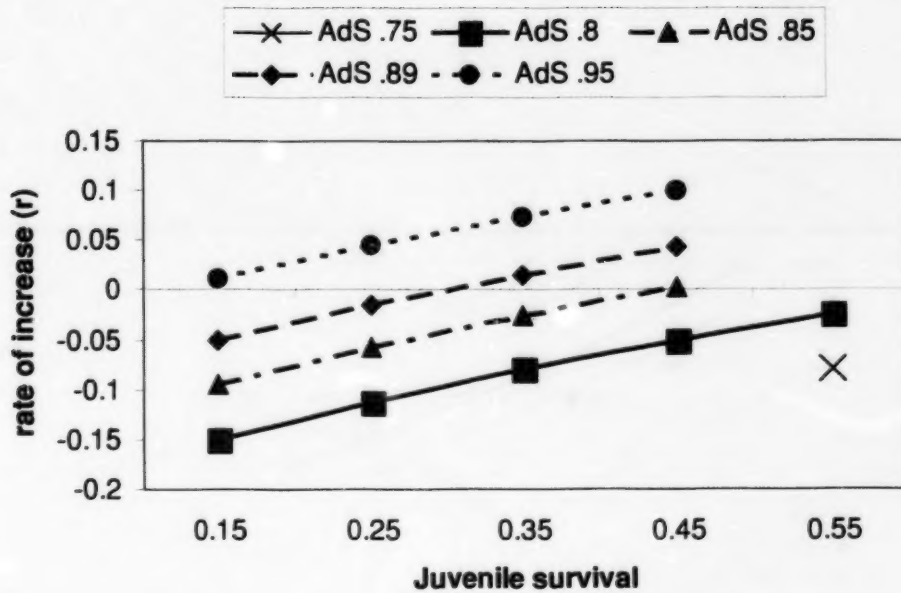


Figure 6. Hypothetical relationships between adult (AdS) and juvenile survival in relation to the population's exponential rate of increase (r). Assumptions behind the model include: 25% of two-year old females produce young, 90% of older females produce young, one young produced per reproductive female, and survival from one to two years of age is 0.75.

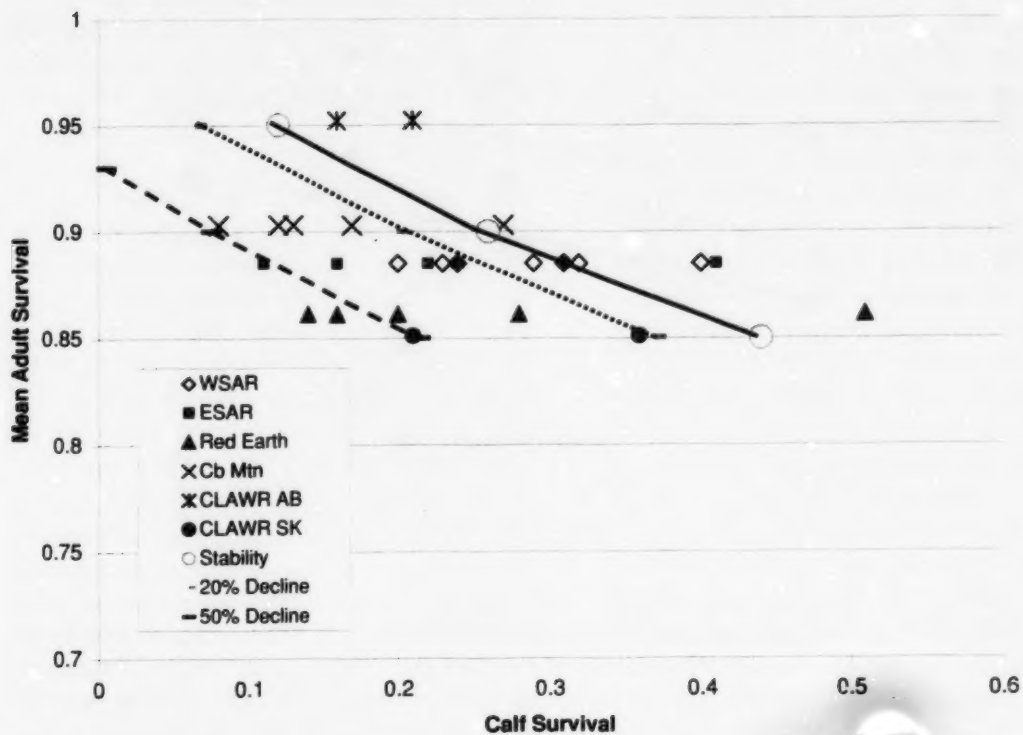


Figure 7. Average female survival (based on the geometric average across all years; Steel and Torrie 1980) relative to estimated calf survival for six ranges of Woodland Caribou in northern Alberta (Boreal Caribou Research Program unpublished data). Isopleths represent stable populations, 20% decline in 10 years and 50% decline in 10 years (assumptions behind % change are related to 'r' values as calculated in Figure 6).

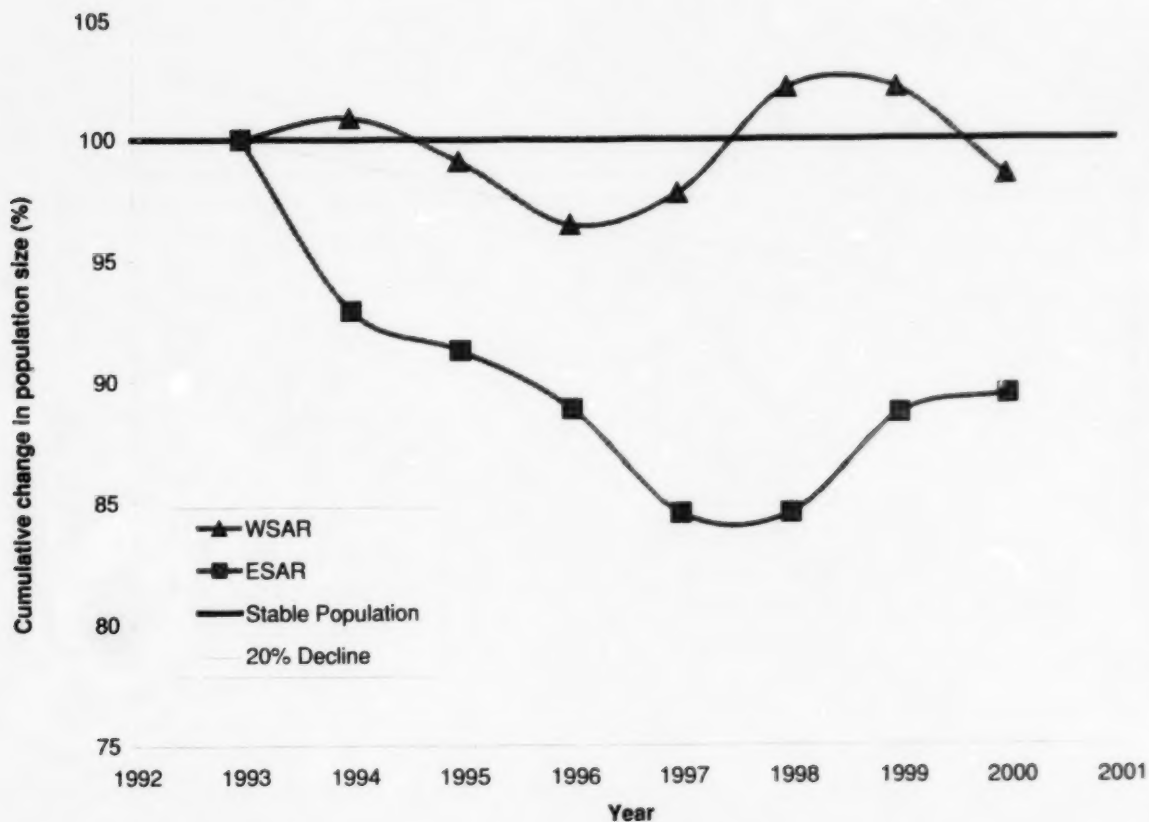


Figure 8. Cumulative change in population size, expressed as a percent, for caribou populations on the west and east sides of the Athabasca River. Population size calculated using rate of increase, r , for each year. Yearly r values were calculated using annual calf recruitment data and a single adult survival rate for each range (based on the geometric average across all years). A Kaplan-Meier procedure (Pollock et al. 1989) was used to estimate adult survival. The 20% reference line shows a population decline of 20% over 20 years (i.e. 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. Note: Figure based on an over estimate of actual calf survival; survival to 10 months is used rather than survival to one year. Actual population declines may therefore be greater and population increases may be less than shown.

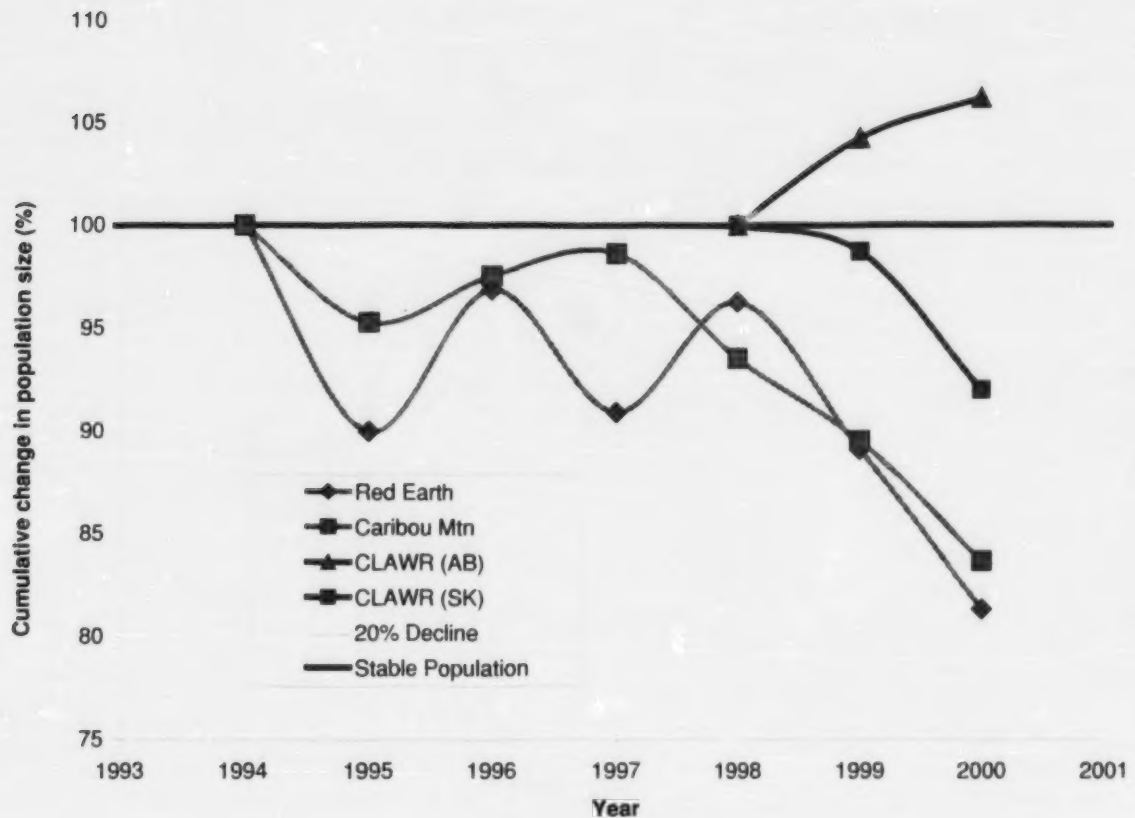


Figure 9. Cumulative change in population size, expressed as a percent, for several boreal caribou populations. Population size calculated using rate of increase, r , for each year. Yearly r values were calculated using annual calf recruitment data and a single adult survival value for each range (based on the geometric average across all years). A Kaplan-Meier procedure (Pollock et al. 1989) was used to estimate the adult survival. The 20% reference line shows a population decline of 20% over 20 years (i.e. 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. Note: Figure based on an over estimate of actual calf survival; survival to 10 months is used rather than survival to one year. Actual population declines may therefore be greater and population increases may be less than shown.

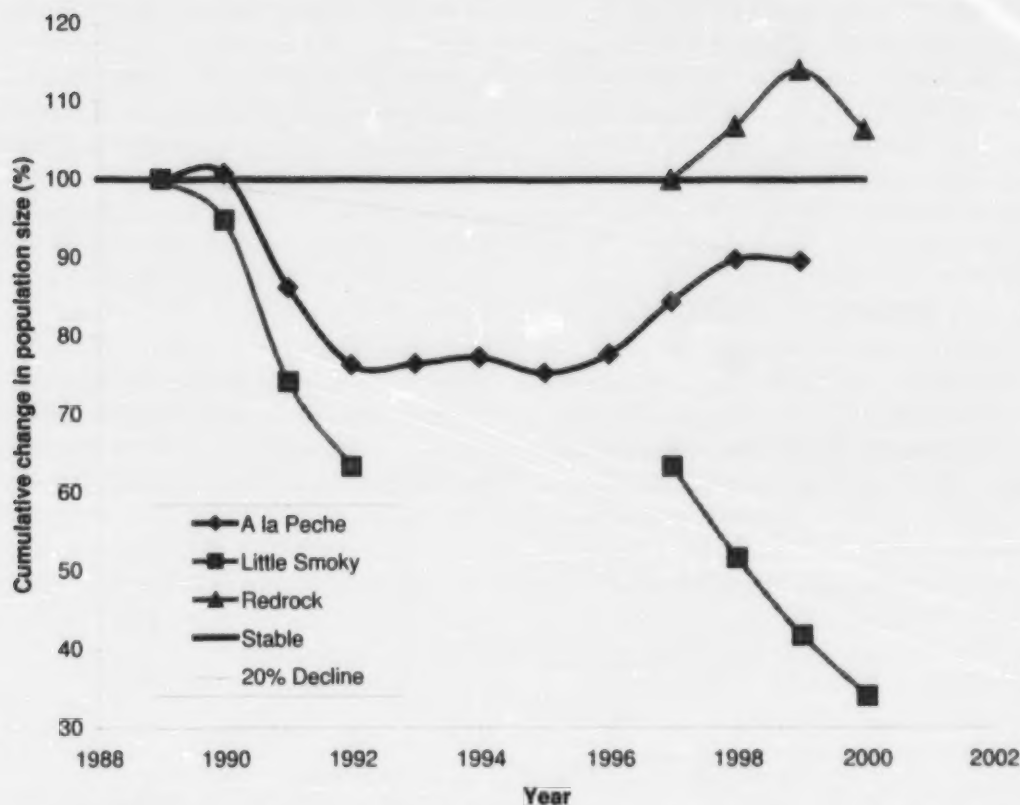


Figure 10. Cumulative change in population size, expressed as a percent, for caribou populations in West Central Alberta. Population size was calculated using rate of increase, r , for each year. Yearly r values were calculated using annual calf recruitment data and a single adult survival rate for each range. The survival rate was calculated using data from the entire monitored time period using a Kaplan-Meier procedure (Pollock et al. 1989). For the A la Pêche range, adult survival rate was adjusted for 1992 and 1993, to account for high known levels of caribou highway mortality. The herd was not being monitored by radio collars at this time. The 20% reference line shows a population decline of 20% over 20 years (3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. Population trends prior to 1998 for Redrock are not plotted due to unclear adult survival rate data.

4. Other Areas. - Despite reservations associated with Woodland Caribou census techniques, Table 2 shows the most recent estimates for Woodland Caribou in other North American jurisdictions. The methods used for determining population size vary from aerial surveys and photo-censuses to 'best guesses' by regional wildlife managers. Readers are encouraged to check with the original authors regarding the reliability of these population estimates and trends.

LIMITING FACTORS

Limiting factors can be discussed in a strict scientific sense, or in more general terms. From the scientific perspective of population ecology, a limiting factor is anything that has

a measurable negative effect on the population's rate of change (Sinclair 1989, Messier 1991, Boutin 1992). In a broader context, limiting factors may be seen as anything that negatively affects either population dynamics or habitat suitability. Changes in habitat quality or quantity may indirectly affect survival or reproduction of an animal and, as such, the two views of limiting factors are inter-related. Indeed, in population ecology it is likely that a number of factors may be limiting at the same time (Watson and Moss 1970). Woodland Caribou, which naturally exist at low density and have low reproductive output, cannot recover from the effects of an array of limiting factors (either alone or in concert) as quickly as species such as deer, elk or moose, which naturally maintain

Table 2. Estimates of both Woodland Caribou abundance and population trends in North America.

Jurisdiction	Population Estimate	Year(s) of Estimate	Population Trend by Herd or Jurisdiction	References
YK	29 000 - 35 000	1978 - 1998	17% Increasing 9% Decreasing 35% Stable 39% Unknown	(Farnell et al. 1998) (R. Farnell, pers. comm.)
BC	18 000	1996	15% Increasing 10% Decreasing 31% Stable 44% Unknown	(Heard and Vagt 1998)
WA/ID	<100	?	?	(Washington Department of Fish and Wildlife 1997)
SK	2500	?	Unknown	(Kelsall 1984)
MB	2000 - 2500	1973 - 1990	Unknown	(Johnson 1993)
ON	20 757	1982 - 1996	Variable	(Cumming 1998)
QC/Lab herds Gaspésie Park Other herds	200 - 250 <1,000	1980s 1997	Stable Variable	(Crête et al. 1994, Schaefer 1997a,b, C. Found, pers. comm.)
NF (island)	>80 000	1989 - 1998	11 herds increasing 5 herds stable 2 herds decreasing	(C. Doucet, pers. comm.)

higher population densities and are more productive. The following is a discussion of limiting factors, in the strict and broad sense, that may be affecting Woodland Caribou.

1. Predation. - Predation is an important limiting factor for caribou populations. In order to reduce the impact of predation, Woodland Caribou remove themselves spatially from other ungulate prey (Bergerud and Page 1987, Seip 1992). Caribou accomplish these spacing strategies through seasonal migrations (e.g., some areas of west-central Alberta; Edmonds 1988, Edmonds and Smith 1991) and/or by being sparsely distributed in very large range areas (Bergerud 1980, Bergerud et al. 1984) that contain lower densities of alternate prey (e.g., boreal ecotype caribou in peatland complexes [James 1999]; some west-central Alberta winter ranges [Alberta Environment, unpubl. data, D. Hervieux, pers. comm.]). Various factors, such as human intervention, can affect the vulnerability of caribou to predation by affecting caribou condition/behaviour or predator abundance/behaviour. Caribou have co-existed with wolves and other predators for thousands of years, however, human alterations of ecological relationships have important implications for the persistence of Woodland Caribou in Alberta. Interactions between predation and other factors such as habitat alteration (timber harvesting, linear corridors, alternate prey, etc.), human activity (recreation, road use, etc.), or weather are complex.

Predator control, be it direct (lethal) or indirect (fertility control), is espoused by some as the logical method for altering predator abundance sufficiently to allow for an improvement in caribou survival and population growth. Although survival and population growth of ungulates may respond to predator control, the results are not consistent, especially in multiple predator-prey systems (Committee on

Management of Wolf and Bear Populations in Alaska 1997). Furthermore, justification for predator control is increasingly difficult to achieve given changing societal values.

The following sections include discussions that relate predator-caribou dynamics to other limiting factors.

2. Habitat Loss and Alteration. - Woodland Caribou require large tracts of old forest that contain lichens. Natural or human-caused disturbances can alter such habitat features significantly. Many biologists have postulated that habitat loss is a major limiting factor for caribou populations (Edwards 1954, Bloomfield 1980a). However, Bergerud (1983) found little support for a cause and effect relationship between habitat loss and population declines. True loss of caribou habitat probably only occurs as a result of permanent modifications of the habitat associated with land-use conversion (e.g., forest to agricultural land, as has occurred in the Deadwood caribou range; D. Moyles, pers. comm.). If forests altered by fires or logging were allowed to follow a natural successional path, most habitat 'loss' would be better defined along a gradient of habitat alteration. However, if regenerating forests are subsequently scheduled for harvesting before they reach an age at which they can sustain lichens (and caribou), then habitat alteration effectively becomes habitat loss.

Large-scale habitat change as a result of logging or fire has both direct and indirect effects on caribou ecology. There is an immediate loss of habitat if forests, and associated lichens, are destroyed or significantly reduced. Also, barriers to movement through windfall and alteration of snow cover characteristics may be created (Kelsall et al. 1977, Davis and Franzmann 1979, Klein 1982, Schaefer and Pruitt Jr. 1991).

Subsequently in many areas, and as a part of natural forest succession, there would be an increase in deer, elk, and/or moose populations that thrive on young regenerating forest. An increase in other ungulates will lead to increases in wolf numbers (i.e., a numerical response) or changes in the distribution of wolves (and possibly bears) which could lead to increased predation rates on caribou (Seip 1992). James (1999) speculates that caribou in northeastern Alberta may experience at least an order of magnitude increase in predation rates if other ungulates increase to levels that provide a sufficient prey base to allow wolves to occupy caribou range year round. Bergerud (1974) proposed that it was not the initial loss or alteration of habitat that caused the decline and range recession of caribou in many areas of North America, but rather the secondary effects associated with overhunting and increased predation.

Fire is the dominant force shaping the boreal forest of Alberta (Rowe and Scotter 1973) and has important implications for caribou populations. In the short term, fire is detrimental to caribou habitat, however, in the long term fire may be required to alter landscape vegetation characteristics, allowing lichen biomass to be maintained or increased (Scotter 1970, Schaefer and Pruitt Jr. 1991, Thomas 1998). Conversely, forestry activity on caribou winter range in west-central Alberta is thought to have negatively affected mountain caribou populations (Bjorge 1984, Edmonds and Bloomfield 1984, Edmonds 1988). Through analysis of long-term data sets in west-central Alberta, Smith et al. (2000) documented reductions in herd distribution, daily movement rates and individual winter range sizes as timber harvesting progressed; the avoidance of habitats fragmented by logging caused caribou to concentrate in unlogged portions of their winter range. Ecological compression of caribou runs

counter to their adaptive strategy of remaining at low density within large range areas and could result in increased predation. In the absence of specific long-term habitat supply plans which include annual allowable cut accommodations, logging in west-central Alberta will not allow for a suitable amount and spatial distribution of appropriate forest age classes on the landscape to permit long-term caribou conservation (D. Hervieux, pers. comm.). As outlined in current industry timber planning submissions to Alberta Environment, large volumes of timber covering large areas will be harvested from west central caribou ranges in the coming years and decades. There is also concern that commercial logging may not be equivalent to wildfire in creating optimal conditions for the renewal of lichen growth (D. Hervieux, pers. comm.).

In the boreal regions of Alberta, timber harvesting in black spruce/larch forests is not currently cost effective. Although caribou in the peatlands of northern Alberta are not currently at risk from large-scale forestry operations in their habitat, they may be at risk from indirect effects of timber harvesting in upland areas adjacent to peatland complexes (Note: Caribou in the Chinchaga area of northern Alberta use commercial upland forest during deep snow periods; Hornbeck and Moyles 1995). Although the magnitude of change is uncertain, the relationship between timber harvesting in or near caribou range and its subsequent effects on predator/caribou dynamics has a strong theoretical basis (Seip 1992, Messier 1994, Cumming et al. 1996, James 1999). Hypothesized increases in moose, and subsequently wolves, following fire or timber harvesting may not occur depending on the amount and type of access for human hunters following the disturbance (Rempel et al. 1997). While the potential effects of overlapping moose/wolf/caribou habitat are ecologically intriguing, and

potentially very detrimental to Woodland Caribou populations, there is little empirical evidence to support or refute the proposed relationships (Boer 1997).

Extensive oil and gas deposits underlie most caribou ranges in Alberta. Very high levels of petroleum and natural gas exploration and development have taken place in most of Alberta's caribou management zones during the last 10 to 20 years, and the extent and intensity of this work has dramatically accelerated in recent years (R. Woods pers. comm.). In the Little Smoky range 48% of the total range area was covered by intensive and overlapping industrial work (mostly "3-D" seismic) in the winter of 1999-2000 (Alberta Environment unpub. data). In the early winter of 2000-2001, 54% of the Little Smoky range area had similar proposals for industrial work; current discussions between Alberta Environment and proponents are attempting to reduce this figure. With the exception of parts of the Caribou Mountains and Bistcho caribou ranges (Figure 1), subsurface mineral rights are currently leased throughout most of the area of all caribou ranges in the province (Alberta Resource Development unpub. data). In west central caribou ranges in particular, a large number of land parcels have recently been leased under the mineral sales process (D. Hervieux, pers. comm.). The northern peatlands also hold some of the best horticultural peat in North America (e.g., east of Wabasca; G. Samide, pers. comm.); extraction of this resource has begun.

Habitat supply is an obvious challenge for caribou conservation in west central Alberta, and applies to the boreal region if the direct or indirect effects of all industrial activity cause caribou to avoid heavily developed areas (see below). Resource extraction in the form of forestry, petroleum and natural gas exploration and production, mining (coal, peat and potentially diamonds), and agricultural

expansion all have the potential to negatively affect caribou in Alberta. The challenge for caribou conservation is to maintain sufficient quantities of suitable habitat through time within each caribou range, and not unduly increase predation pressure, in order to avoid local extirpation of caribou populations.

3. Linear Corridors, Human Activity and Effects on Predator Ecology. - Fragmentation of habitat by linear corridors (i.e., pipelines, roads, seismic lines, transmission corridors) or forestry cutblocks may have a number of effects on caribou movements, distribution, and survival. Corridors provide access for humans and predators to penetrate vast tracts of wilderness caribou range that formerly was not easily accessible. Licensed harvest of caribou has not been allowed in Alberta since 1981. The extent of caribou mortality from hunting by First Nation's, and non-licensed poaching, is unknown and probably varies between areas. Some small caribou groups northwest of Manning are known to have been recently eliminated because of hunting activity (D. Moyles, pers. comm.). It has been suggested that the lack of predictability in movements of boreal ecotype caribou reduced the risks associated with overhunting (Bradshaw and Hebert 1996). While this may be true in a natural situation, the current proliferation of linear corridors associated with resource extraction, together with the natural curiosity of caribou, may compromise the survival strategies of these animals. Improved access into caribou range as a result of an expanding network of linear corridors in addition to expanding use of all-terrain vehicles could lead to increased legal and illegal hunting of caribou. Careful planning and regulation of access development within caribou range is needed to minimize these risks.

Human use of linear corridors also has the potential to increase traffic collisions with Woodland Caribou. Vehicle collisions with

caribou have been problematic along a section of Highway 40 (south of the town of Grande Cache in west-central Alberta) that bisects the traditional winter range of the A La Pêche herd. During the winters of 1991/92 and 1992/93, at least 32 caribou were hit on this highway resulting in 27 known caribou deaths (Brown and Ross 1994) from an estimated total population of 150 to 200 caribou (Brown and Hobson 1998). A program of active deterrence and monitoring may reduce collisions as only one to four caribou are known to have died annually in recent years on Highway 40 (Brown and Hobson 1998). However, in recent years highway mortality may have been reduced because most of the A La Pêche population has remained in the mountains during winter, for unknown reasons (K. Smith, pers comm.). With increasing road infrastructure in caribou habitat, the potential exists for collisions to increase in other areas of the province.

Linear corridors or cutblocks may also affect caribou population dynamics by altering the movements and distribution of both predators and prey and increasing predation pressure on caribou. Caribou, other ungulates, and omnivorous predators such as bears may be attracted to the vegetation surrounding linear corridors and well sites. Furthermore, wolves make use of linear corridors as travel paths (Thurber et al. 1994) and were found to travel faster on corridors than in forest during winter (James and Stuart-Smith 2000). Corridors penetrating caribou habitat may thus allow for a significant increase in encounter rates between predators and caribou. In a recent telemetry study in northeastern Alberta, the mortality sites of radio-collared caribou that died from wolf predation were significantly closer to linear corridors than the locations of caribou that were alive (James and Stuart-Smith 2000).

Disturbance, increased energy expenditure, habitat alienation, and avoidance of human activities, are issues of concern for caribou ecology in relation to linear corridors. Fuller and Keith (1981) and Edmonds (1988, 1991) have implicated petroleum exploration and development as possible causes of decline of caribou in Alberta. Caribou in northern Alberta exposed to simulated elements of seismic activity showed higher mean movement rates and linear displacement relative to control animals, but feeding patterns were not affected by the disturbance (Bradshaw et al. 1997, Bradshaw et al. 1998). Caribou behavioural responses (displacement/avoidance) have been demonstrated in oilfields in Alaska (Dau and Cameron 1986, Murphy and Curatolo 1987, Nellemann and Cameron 1996). Recently completed work in northern Alberta is the first study on Woodland Caribou that demonstrates avoidance and barrier effects of industrial infrastructure (Dyer 1999). GPS-collared caribou avoided human developments to varying degrees. Statistically significant avoidance distances of 250 m (roads and seismic lines) and up to 1000 m (wellsites) were recorded. Using conservative estimates of the spatial distribution of linear corridors in several northern caribou ranges, one can extrapolate the potential area of reduced caribou use relative to human developments. Based on an area of influence of 250 m, the percentage of habitat affected in several northern Alberta caribou ranges varies from 28% to 70% of total range area (Table 3). This avoidance will lead to effective increases in caribou density and predictability of distribution and therefore may contribute to population declines because of increased susceptibility to predation. Seismic lines were not barriers to caribou movements, while roads acted as semi-permeable barriers throughout the year (Dyer 1999). Mountain caribou in west central Alberta were also found to avoid

industrial activities such as cutblocks (Smith et al. 2000) and roads (P. Oberg Graduate Thesis in Prep.). Caribou may become habituated to certain levels of human activity (Cronin et al. 1998), although after two years of intense study habituation has not been clearly demonstrated in northern Alberta (Boreal Caribou Research Program, unpubl. data). While behavioural responses to industrial activity and increased risk of

mortality associated with linear corridors have been shown for caribou, population level responses have yet to be conclusively demonstrated (Bergerud et al. 1984, Cronin et al. 1997). Except in extreme cases, a caribou population response cannot be measured with census techniques available in Alberta. Lack of documentation on a caribou demographic response must not be used as an excuse to ignore the relationships that have been shown

Table 3. Linear corridor density and percentage of range within 250 m of lines in six northern Alberta caribou ranges. Note: all types of linear corridors included (e.g., roads, seismic lines, pipelines, etc.). Estimates are conservative due to difficulty in getting accurate/current data.

Range	Linear Corridor Density (km/km ²)	% of Study Area within 250 m of Linear Corridor
Caribou Mountains	0.7	27.9
Cold Lake	0.89	38.6
Wabasca	1.64	45.3
Red Earth	1.8	55.5
East Side of Athabasca River	2.04	51.9
Chinchaga	2.4	70.2

4. Weather and Climate. - Weather may be considered a limiting factor through a complex set of interactions with caribou movements, habitat use, energetics, reproduction and survival, and as it may affect the abundance or distribution of other ungulates and predators. While caribou are well adapted to winter, conditions can develop that alter their behaviour, reproduction and survival. Bradshaw et al. (1997) found caribou displacement from simulated elements of seismic activity to be significantly less in a year with deeper snow accumulations, implying that snow depth was affecting normal caribou behavior. Also in response to deep or crusted snow, caribou in Alberta have been shown to reduce their daily rate of movement or use habitats with dense stands of trees (Fuller and Keith 1981, Bjorge 1984, Bradshaw et al. 1995, Morton and Wynes 1997, Stuart-Smith et al. 1997, Schneider et al. 1999). In most years,

winter conditions in Alberta are not likely to negatively affect caribou condition, survival or reproduction. However, in winters with above average snowfall and/or severe crusting, caribou condition, reproduction and survival may be compromised. Overwinter reductions in weight are a normal phenomenon in many northern hemisphere ungulates (Clutton-Brock et al. 1982, Adamczewski et al. 1993, Gerhart et al. 1996b). In addition to normal winter stresses, caribou body condition may be further reduced through movements to avoid extensive human activity or through reduced food intake. Variations in weather patterns may also exist over longer time and broader spatial scales. Warming associated with global climate change may alter habitat and caribou population dynamics through increased frequency/severity of forest fires, changes in snow conditions, changes to forage type/quality/abundance, and altered predator-prey

between caribou and human development dynamics. Loss and/or change of Woodland Caribou habitat resulting from altered climatic regimes could potentially overshadow or exacerbate changes associated with industrial development. Such changes in landscape parameters are currently being modeled for caribou in Alberta and Ontario (M. Flannigan and I. Thompson, pers. comm.).

STATUS DESIGNATIONS

1. Alberta. - Woodland Caribou in Alberta are designated as 'threatened' under the Alberta Wildlife Act. In 1991, Woodland Caribou were put on the 'Red List' of at risk species in the province (Alberta Fish and Wildlife 1991). In 1996, the species was moved to the 'Blue List' of may be at risk species in Alberta (Alberta Wildlife Management Division 1996). This redesignation was based on a re-evaluation of data that were more indicative of a 'Blue' ranking (G. Court, pers. comm.). No distinction is made at the provincial level in terms of status of different ecotypes. The Natural Heritage Element Rarity Rank (The Nature Conservancy 2000) for the mountain and foothills populations of the Woodland Caribou in Alberta is S2 (Alberta Natural Heritage Information Centre 2000; see Appendix 1 for explanation of ranks).

2. Other Areas. - The status of Woodland Caribou varies considerably across its former and current range. COSEWIC commissioned an updated status report on Woodland Caribou (Gray 1999) and re-evaluated their status in May 2000. Ecozones or biogeographical units recognized by COSEWIC were used to revise the designation and status of Woodland Caribou (Gray 1999). Of note in this recent review was the reclassification for the Atlantic (Gaspésie) and most of the former western population (COSEWIC 2000). COSEWIC (2000) designates the Woodland Caribou in

Canada as follows: 'extinct' (Queen Charlotte Islands); 'endangered' (Atlantic [Gaspésie]); 'threatened' (the **Boreal population: Alberta, British Columbia, Manitoba, Northwest Territories, Ontario, Saskatchewan;** and the **Southern Mountain population: Alberta, British Columbia;** and 'not at risk' (Newfoundland and the Northern Mountain populations in British Columbia, the Northwest Territories and the Yukon).

In addition to the federal COSEWIC listings, some jurisdictions have their own status designation system. Woodland Caribou in Yukon and most of British Columbia have no designated status and are managed on a herd basis (Yukon Renewable Resources 1996, Heard and Vagt 1998). Mountain ecotype Woodland Caribou in southern British Columbia have been designated by the B.C. Conservation Data Centre as a 'Blue-Listed' species meaning the species is considered vulnerable or sensitive and needing special management to ensure its survival (Heard and Vagt 1998). The mountain ecotype caribou in Washington and Idaho was listed as 'endangered' in 1983 (U. S. Fish and Wildlife Service 1998). No provincially regulated designation exists for Woodland Caribou east of Alberta (exception: Gaspésie population). The global Natural Heritage Element Rarity Rank for the Woodland Caribou is G5T4 where the T rank refers to rare subspecies, varieties, or other recognized taxa below the species level (The Nature Conservancy 2000).

RECENT MANAGEMENT IN ALBERTA

Alberta is currently host to some of the most extensive research and management of Woodland Caribou in North America. Research activities date back to the early 1970s, but the majority of work on caribou in northern Alberta has occurred in the last 10 years.

1. Provincial Initiatives in Caribou Conservation. - Recognition of the need for a provincial management plan began in the late 1970s (Bloomfield 1980b). Since that time, three provincial strategies have been developed and shelved. The 'Woodland Caribou Provincial Restoration Plan' (Edmonds 1986) and the 'Strategy for Conservation of Woodland Caribou in Alberta' (Alberta Fish and Wildlife 1993) were drafted by the provincial wildlife management agency. Few recommendations from these reports were adopted, and the 1993 management plan received considerable criticism from government agencies, public groups and industry (Hervieux et al. 1996).

In November 1993, a multistakeholder committee was formed to scope issues and develop yet another provincial Woodland Caribou conservation strategy. In July 1996, the Alberta Woodland Caribou Conservation Strategy Development Committee delivered a report to the provincial Director of Wildlife Management (Alberta Woodland Caribou Conservation Strategy Development Committee 1996). This conservation strategy recommended a decision-making process, identified information needs and management tools, and proposed specific implementation milestones. The goal was to develop a strategy that would result in "healthy caribou populations in perpetuity throughout Alberta's caribou range", including the removal of Woodland Caribou from Alberta's endangered species list, and eventual restoration of a limited licensed hunting season. The 1996 conservation strategy has not been approved by Alberta Environment. However, Alberta Environment staff and a number of stakeholders have used the strategy for guidance in the planning and implementation of resource management activities on Woodland Caribou range (D. Culbert, pers.

comm.). The lack of endorsement of senior government officials has been viewed by some as a lack of commitment to caribou conservation efforts.

2. Regional Caribou Research and Management Initiatives. - In the 1980s, concerns about a lack of caribou conservation measures together with increasing confrontations between government regulators and industrial operators resulted in the establishment of local or regional multi-stakeholder committees. Creation of these committees was facilitated by a provincial government information letter (IL 91-17) that stated '...industrial activity could occur on caribou range provided that the integrity and supply of habitat is maintained to permit its use by caribou' (Alberta Energy 1991, Alberta Energy 1994, Alberta Energy 1996). While this directive dealt primarily at the petroleum and natural gas industry, the 'spirit' of the letter has been adopted by the committees for application to all industries operating on caribou range. This approach to managing land-use activities has improved working relationships in many cases and helped to establish well-funded research programs (Rippin et al. 1996, Dzus and Boutin 1998, Hamilton and Edey 1998). The goal is to establish a knowledge-based management plan that will allow caribou conservation and resource extraction on the same land base. Although benefits are accrued by all participants (Edey et al. 1998), all current caribou/industry land-use guidelines continue to be challenged annually by various stakeholders. Current land use guidelines for industrial activities on caribou range in northern Alberta have been demonstrated to be ineffective in terms of providing for long term caribou conservation (Boreal Caribou Research Program 1999b). An attempt is being made to revise these guidelines to incorporate knowledge garnered through the research

programs (R. Woods, pers. comm.). The ultimate success of this transition from confrontation to collaboration would be to conserve caribou populations throughout their range in Alberta.

3. Research and management in west-central Alberta. - Hervieux et al. (1996) provided a review of management activities with regards to caribou conservation in west central Alberta. The West Central Alberta Caribou Standing Committee (WCACSC) was formed in 1992. As with similar initiatives in northern Alberta (see below), the committee's primary goals were to provide a forum for multi-stakeholder communication and decision-making with regard to industrial land-use guidelines that would help conserve caribou in west central Alberta. Operating guidelines for industrial activity on caribou range were established in 1996 (West Central Alberta Caribou Standing Committee 1996).

Because of direct conflict between caribou habitat requirements and forestry activities in west central Alberta, the Habitat Supply Subcommittee of the WCACSC has an important role in developing long term timber management plans that will ensure sufficient habitat for caribou on each range. To date this subcommittee has been unable to reach consensus on a unified approach to evaluate, plan, or maintain habitat supply (D. Hervieux, pers. comm.). Despite lack of progress on long term habitat supply, there have been several management initiatives that show promise for mitigating or reducing the effects of industrial activity on caribou range in west-central Alberta (D. Hervieux, pers. comm.). Weyerhaeuser Canada (Grande Prairie and Grande Cache) in collaboration with Alberta Environment have established a new timber planning system that abandons current provincial and company timber harvesting ground rules and current timber planning

procedures. Some of the new elements include: establishing long term targets for habitat quality, distribution and effective range area, considering caribou habitat needs during calculation of annual allowable cut, large block harvesting within a multiple entry system, and reducing road tenure and standards. Despite considerable progress, Alberta Environment and Weyerhaeuser have not reached consensus on all points (D. Hervieux, pers. comm.).

Throughout west central caribou ranges many petroleum and natural gas companies have largely accepted a "no all-weather roads policy" to access new wells. Many new wells are being produced through remote metering techniques, although sour gas, oil, water infiltration, high pressure and other production issues continue to make a broad achievement problematic (D. Hervieux, pers. comm.). In west central caribou ranges seismic activities are conducted through either heli-portable or low-impact techniques, with a January 15 to April 30 no work window target.

4. Research and management in northern Alberta. - The ecology of Woodland Caribou (boreal ecotype) in northern Alberta remained largely unknown until the early 1990s. In 1990, the Pedigree Standing Committee was formed, followed by the Northeast Regional Standing Committee on Woodland Caribou (NERSC) in 1991, the Northwest Regional Standing Committee on Woodland Caribou (NWRSCC) in 1992, the Slave Lake Committee in 1993, and the Red Earth Standing Committee on Caribou in 1995. Similarities in caribou ecology and management issues throughout northern Alberta led to the merger in 1999 of the former NERSC and NWRSCC into the Boreal Caribou Committee (BCC). As with the regional committee in west central Alberta, an adaptive management strategy was established and operating guidelines are reviewed periodically (Northeast Regional

Standing Committee on Woodland Caribou 1997, Northwest Regional Standing Committee on Woodland Caribou 1997). As with any adaptive management approach, the guidelines currently in place are interim. The guidelines have been shown to be ineffective at conserving caribou and their habitat (Boreal Caribou Research Program 1999b). In September 1999, following completion of several research projects, a comprehensive revision of landuse guidelines in northern Alberta was initiated. It is hoped that revised guidelines will incorporate knowledge gained since the inception of NERSC and NWRSCC and more clearly provide for long term caribou conservation.

See Appendix 4 for more details on research and management activities occurring in Alberta.

SYNTHESIS

Woodland Caribou were designated as a 'threatened' species in Alberta as a result of reductions in distribution, declines in regional populations and a threat of further population declines associated with human activities. As of July 1996, the provincial population was estimated to be between 3600 and 6700 caribou. While population dynamics often exhibit annual variation in survival of adults and juveniles, the trend for most caribou ranges studied in Alberta is one of decline. In some cases the declines may be offset by periodic years of high survival. However, juvenile survival rates have been in a range whereby statistical overestimates in calculating adult survival (due to low sample size in some years) may provide inappropriate optimism. The longer-term sustainability of caribou populations in Alberta is uncertain given rapidly expanding human activities on and near caribou range. The current extent of linear developments has reduced habitat

effectiveness on 28% to 70% of the habitat in the major northern caribou ranges assessed. Reductions in industrial activity and associated human activity are not anticipated within Alberta's caribou ranges in the foreseeable future.

The collaborative research and management activities being undertaken by the various regional standing committees have dramatically increased our knowledge of caribou ecology. It is now critical to build our knowledge base beyond basic ecology to better understand the effects of industrial activity on caribou and their habitat. Essential studies are now underway using GPS and GIS technology to simultaneously evaluate caribou and human use on the same caribou range. We also need a better understanding of the effects of logging on lichen ecology and predator-prey dynamics. Synthesizing all information on caribou ranges in the form of cumulative effect assessments is another essential element of ongoing research programs. Innovative census techniques need to be developed to enable wildlife biologists to improve their estimates of the size of caribou populations. Concurrent with the aforementioned research projects, periodic monitoring of caribou population dynamics must continue on each caribou range.

Research alone will not ensure the continuation of Alberta's caribou populations; current land-use guidelines must be reviewed, improved, implemented, and adhered to. In some cases guidelines have yet to be created to manage certain aspects of industrial activity (e.g., silviculture for lichen regeneration, habitat supply planning, cumulative effects assessment and application, peat extraction, etc.). In areas of west central Alberta, where caribou and forestry companies are in direct competition for the same land base, it is essential that long term habitat supply issues are addressed. Similarly in both northern and west central

ranges, the issue of habitat degradation resulting from linear corridors needs to be addressed within a habitat supply framework. As multiple land-use activities are being conducted simultaneously on the same land base, there must be better coordination of operations among stakeholders. An obvious step to minimize the direct and indirect effects of all types of industrial activities is to minimize the size, distribution, amount, standard, and duration of linear corridors. Benchmark areas should be given serious consideration within the suite of land management alternatives. Some of the biggest deterrents to effective conservation lie in the realm of government policy and industry business practices. An independent audit of policies and industrial practices relative to caribou conservation is recommended as a way to evaluate and develop more effective management of caribou range.

Industrial activity has been allowed on caribou range in Alberta "provided the integrity of the habitat is maintained to support its use by caribou" (Alberta Energy 1991). The current

distribution, intensity, amount and type of human activity on and near caribou range, is compromising the 'integrity' of caribou habitat. To correct this situation the following actions are needed: (1) develop and rigorously implement land use guidelines that address research findings; these guidelines should deal with cumulative effects; (2) continue research and monitoring programs, and review government and industry policies and practices which limit caribou conservation. New information and constructive changes to policies and practices must be applied as they become available; (3) and cumulative effects thresholds must be developed and incorporated into management of caribou ranges as part of a comprehensive strategy to integrate caribou conservation and human activity on a common land base. The collaborative approach to conservation of Woodland Caribou has the potential to be successful in terms of maintaining caribou in perpetuity. However, there must be 1) effective techniques for managing factors influencing caribou and their habitat, and 2) the will (political, societal, business) to ensure such success.

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APPENDIX 1. Definitions of selected legal and protective designations.

A. Status of Alberta Wildlife colour lists (after Alberta Wildlife Management Division 1996)

Red	Current knowledge suggests that these species are at risk. These species have declined, or are in immediate danger of declining, to a nonviable population size.
Blue	Current knowledge suggests that these species may be at risk. These species have undergone non-cyclical declines in population or habitat, or reductions in provincial distribution.
Yellow	Species that are not currently at risk, but may require special management to address concerns related to naturally low populations, limited provincial distributions, or demographic/life history features that make them vulnerable to human-related changes in the environment.
Green	Species not considered to be at risk. Populations are stable and key habitats are generally secure.
Undetermined	Species not known to be at risk, but insufficient information is available to determine status.

B. Alberta Wildlife Act

Species designated as 'endangered' under the Alberta Wildlife Act include those defined as 'endangered' or 'threatened' by A Policy for the Management of Threatened Wildlife in Alberta (Alberta Fish and Wildlife 1985):

Endangered	A species whose present existence in Alberta is in danger of extinction within the next decade.
Threatened	A species that is likely to become endangered if the factors causing its vulnerability are not reversed.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2000)

Extinct	A wildlife species that no longer exists.
Extirpated	A wildlife species that no longer exists in the wild in Canada, but exists elsewhere in the wild.
Endangered	A wildlife species that is facing imminent extirpation or extinction.
Threatened	A wildlife species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern (Vulnerable)	A wildlife species of special concern because it is particularly sensitive to human activities or natural events, but does not include an extirpated, endangered or threatened species.
Not at Risk	A wildlife species that has been evaluated and found to be not at risk.
Indeterminate	A species for which there is insufficient scientific information to support status designations.

D. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

E. Natural Heritage Element Rarity Ranks (after The Nature Conservancy 2000)

G1 / S1	Critically Imperiled: Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or linear miles (<10).
G2 / S2	Imperiled: Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000) or acres (2,000 to 10,000) or linear miles (10 to 50).
G3 / S3	Vulnerable: Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.
G4 / S4	Apparently Secure: Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.
G5 / S5	Secure: Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

B - A rank modifier indicating breeding status for a migratory species.

N - A rank modifier indicating non-breeding status of a migratory species.

APPENDIX 2. Movement of Individual Caribou between Ranges

1. West Central Alberta

The four caribou ranges in West Central Alberta (Narraway, Redrock/Prairie Creek, Little Smoky and A La Peche) are believed to contain four separate/non intermixing caribou populations.

During the period 1980 to 2000, in excess of 150 caribou have been radio collared in west-central Alberta. Collars have been put out in all four caribou ranges. Over the twenty years of record only one instance of possible movement (by one individual) between caribou ranges was observed; in the early 1980's one male caribou moved from the Redrock/Prairie Creek range to summer and then winter in the mountains of south Willmore park. This area is considered summer range of the A La Peche population. There are no other observations of radio collared animals moving between any West Central ranges. All four west-central caribou populations are known to have widely separated and distinct breeding areas.

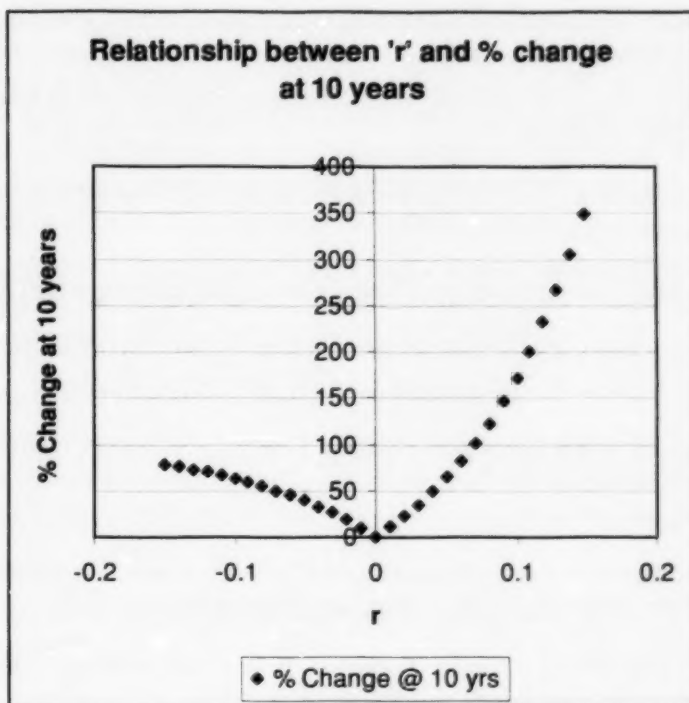
2. Northern Alberta

Over the course of the last decade, in excess of 300 individual caribou have been radio collared in Northern Alberta. Caribou have been radio collared in most of the identified caribou ranges. No movement of caribou has been observed between the Caribou Mountains and any other range. Similarly, no movement of caribou has been recorded between Red Earth and any other range. Limited movement has been observed between west side of the Athabasca and east side of the Athabasca; three radio collared animals crossed the Athabasca river. There have been no recorded movement of caribou between the east side of the Athabasca and the Cold Lake Air Weapons caribou range. There is no record of caribou movement out of or into Chinchaga, Deadwood or Hotchkiss caribou ranges. As well there is no record of caribou movement in or out of the Slave Lake range.

With the exception of west side and east side of the Athabasca, all of the caribou ranges in Northern Alberta appear to be separate /non intermixing caribou populations.

Source: B. Wynes and J. Ficht, pers. comm.

APPENDIX 3. Relationship between exponential rate of increase (r) and percentage change in population at 10 years.



APPENDIX 4. Recent and Ongoing Research Activities Involving Woodland Caribou and Their Habitat in Alberta

As of 1998 a research strategy was approved by the Research Subcommittee of the WCACSC. Until recently, research in west-central Alberta has been conducted by government agencies and individual companies. Studies have included:

- Preparation of a summary of knowledge of caribou ecology to date in west-central Alberta (Brown and Hobson 1998);
- Annual surveys of caribou to monitor population characteristics on all ranges (Edmonds 1988, Edmonds and Smith 1991);
- Radio telemetry studies are ongoing on all west-central caribou ranges (1995 to present);
- A caribou sighting card system is also administered by Alberta Environment (1983 to present) with data being entered in the Biodiversity Species Observation Database;
- Telemetry studies on winter range and evaluating habitat use versus availability and caribou response to timber harvest on the Redrock/Prairie Creek range (sporadically since 1982; Smith et al., 2000);
- A study of winter habitat use on Redrock/Prairie Creek range and also evaluated government policies that may be conflicting with caribou conservation objectives (Stepaniuk 1997);
- An examination of the effects of timber harvest on lichens and understory plants on the A la Pêche range (1994 to present; see (Kranrod 1996);
- An examination of the effects of timber thinning on lichen growth on the A la Pêche range (1997 to present; D. Vitt and E. Pharo, pers. comm.);
- A study using GPS-collared caribou in the Redrock/Prairie Creek range to gain a more detailed understanding of movements and habitat use (September 1998 to present; C. Rohner, pers. comm.);
- A 'caribou cowboy/girl' program to reduce collisions with caribou on Highway 40 between Hinton and Grande Cache during the early winter snowfall period (1992 to present);
- An investigation of caribou-vehicle collisions and potential mitigative methods (K. Brown, pers. comm.);
- Monitoring of spring and fall movements of caribou over Caw Ridge (1989 to present) to evaluate mitigative measures that would allow an active coal mining operation through a mitigation corridor (RRCS 1994, Sopuk et al. 1997a,b as cited by Brown and Hobson 1998);
- Individual-based and spatially explicit caribou model for population viability analysis and cumulative effects assessment (C. Rohner, pers. comm.).

- A study investigating predation risk by wolves in relation to development was initiated in 1999 (G. Kuzyk, pers. comm.).

The Northeast and Northwest Standing Committees on Woodland Caribou initiated studies of population dynamics, movements, distribution, habitat use and the effects of access and disturbance in their respective regions during the early 1990's. It was decided in 1996 that the ecology of caribou and the general characteristics of industrial activity on caribou range (primarily oil & natural gas) in northern Alberta were similar enough to formalize a collaborative research initiative. In July 1996, the Boreal Caribou Research Program (BCRP) was formed (see <http://www.deer.rr.ualberta.ca/caribou/bcrp.htm>). The following projects are ongoing or have been recently completed by BCRP researchers in northern Alberta:

- Since 1992 more than 300 caribou have been captured and radio-collared; regular monitoring of continues on five broad study areas (Boreal Caribou Research Program 1998, 1999, Dzus et al. in prep., Morton and Wynes 1997, and Stuart-Smith et al. 1997);
- Use of sighting cards similar to that in west-central Alberta;
- Examination of habitat use by caribou in peatlands (Anderson 1999, Bradshaw et al. 1995)
- Identification of habitat by GPS-collared caribou using Landsat TM imagery (Bechtel et al. 2000);
- Examination of habitat use in relation to recent fires (BOREAL CARIBOU RESEARCH PROGRAM, unpubl. data);
- Examination of moose/caribou/wolf interactions on the Wabasca and Agnes ranges from 1994 to 1997 (James 1999, James and Stuart-Smith 2000);
- Investigation of the response of caribou to simulated elements of seismic activity (Bradshaw 1994, Bradshaw et al. 1997, Bradshaw et al. 1998);
- Examination of survival of caribou and use of linear corridors by caribou and wolves (James and Stuart-Smith 2000);
- Investigation of survival of caribou in relation to differing densities of linear corridors;
- Survival of caribou in an area of restricted human access is being investigated on the Cold Lake Air Weapons Range;
- A simultaneous investigation of caribou and human use of the Wabasca area (Dyer 1999), and;
- Examination of the cumulative effects of industrial activity on Woodland Caribou in the Wabasca range. This study will be the primary focus of BCRP research in the next four years.

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